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14. ABSTRACT

The United States military has been vigorously engaged throughout the full range of military operations during the course of the past two decades. Since gaining prominence during the withdrawal of U.S. forces in Somalia in 1995, non-lethal weapons have taken on an increasing role as our armed forces continue down the road toward doctrinal and technological transformation. While providing an option somewhere between the realm of "shoot" or "don't shoot", the utility of items such as rubber bullets, beanbag projectiles, and flash-bang grenades during looting, rioting, and similar unfavorable activities appears to be definitive and enduring. The need for non-lethal weapons during large-scale combat operations might not be so apparent. This leads to a fundamental question. Do non-lethal weapons have a legitimate battlefield role in major combat operations? This paper examines the need for non-lethal weapons in combat operations and considers the debate surrounding their implementation.

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THE NEED FOR NON-LETHAL WEAPONS IN MAJOR COMBAT OPERATIONS

by

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A paper submitted to the Faculty of the Naval War College in partial satisfaction of the requirements of the Department of Joint Military Operations.

The contents of this paper reflect my own personal views and are not necessarily endorsed by the Naval War College or the Department of the Navy.

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Abstract

The United States military has been vigorously engaged throughout the full range of military operations during the course of the past two decades. Since gaining prominence during the withdrawal of U.S. forces in Somalia in 1995, non-lethal weapons have taken on an increasing role as our armed forces continue down the road toward doctrinal and technological transformation. While providing an option somewhere between the realm of "shoot" or "don't shoot", the utility of items such as rubber bullets, beanbag projectiles, and flash-bang grenades during looting, rioting, and similar unfavorable activities appears to be definitive and enduring. The need for non-lethal weapons during large-scale combat operations might not be so apparent. This leads to a fundamental question. Do non-lethal weapons have a legitimate battlefield role in major combat operations? This paper examines the need for non-lethal weapons in combat operations and considers the challenges towards their implementation.

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Introduction

The United States military has been vigorously engaged across the full range of military operations during the course of the past two decades. From peacekeeping missions in Somalia, Bosnia, and Kosovo to major combat operations in Afghanistan and Iraq, the U.S. military has found itself engaged in virtually every endeavor short of global war. As a result, the Department of Defense has pursued, developed, and fielded many revolutionary technologies and concepts to cope with the vast assortment of challenges it has encountered. In this environment, non-lethal weapons (NLWs) have emerged as technologies possessing great potential. Since gaining prominence during the withdrawal of U.S. forces in Somalia in 1995, non-lethal weapons have taken on an increasing role as our armed forces continue down the road toward doctrinal and technological transformation.

U.S. military commitments during this 20 year timeframe have been weighted towards peace operations and nation assistance. While providing an option somewhere between the realm of "shoot" or "don't shoot", the utility of items such as rubber bullets, beanbag projectiles, and flash-bang grenades during looting, rioting, and other unfavorable activities appears to be definitive and enduring. However, our armed forces must be prepared to achieve national strategic objectives in the event that our country's leadership elects to conduct major operations or campaigns involving large-scale combat.[1] The need for non-lethal weapons during such large-scale

combat operations might not be so apparent. This leads to a fundamental question. Do non-lethal weapons have a legitimate battlefield role in major combat operations or should they be relegated only to non-combat roles such as humanitarian and security cooperation efforts? The purpose of this paper is to discuss why an operational commander might want to consider NLWs during the planning and execution phases of a major combat operation. In essence, this paper deals with the relevancy of non-lethal weapons as they to pertain to the concept of "winning the war" versus their utility in "keeping the peace". As such, the thesis of this paper is that there is a necessity for non-lethal weapons in the realm of major combat.

What is a Non-Lethal Weapon?

The Department of Defense defines non-lethal weapons as "discriminate weapons that are explicitly designed and employed to incapacitate personnel or materiel, while minimizing fatalities and undesired damage to property and environment."[2]

The particular term "non-lethal weapon" and its associated definition have been targets of criticism while proving to be somewhat contentious. To begin with, the phrase "non-lethal" is a bit of a misnomer as there is no requirement that a NLW be incapable of killing or of causing permanent damage.[3] For example, the British Army fired some 125,000 plastic/rubber bullets causing 17 deaths and hundreds of heavy casualties during a 25 year

security commitment in Northern Ireland.[4] DOD policy specifically states that NLWs "shall not be required to have a zero probability of producing fatalities or permanent injuries."[5] At the same time the policy maintains that "while complete avoidance of these effects is not guaranteed or expected, when properly employed, non-lethal weapons should significantly reduce them as compared with physically destroying the same target."[6] Alternative terms such as "near-lethal" or "less-than-lethal," as adopted by the Department of Justice, have not had as lasting of an impression.[7]

To compound the difficulty in achieving a precise understanding of the term, a definition for the word "weapon" cannot be found in the Department of Defense Dictionary of Military and Associated Terms.[8] The Oxford Dictionary defines a weapon as a "thing designed or used for inflicting bodily harm or physical damage" but also as "a means of gaining an advantage or defending oneself."[9] In a sense, the "weapon" portion of non-lethal weapon encompasses aspects of both definitions as the program includes technologies that are not exclusively things, but also systems and means.

While the previous paragraphs may appear to be an unnecessary discourse in semantics, it is important to understand the context of terms as they will be referred to throughout the rest of this paper. Likewise the debate regarding the exact meaning of this term extends beyond the scope of this reading. The particular interpretation and application of the term non-lethal weapon has significant relevance as it possesses the potential to

influence policies towards their use and even their legality with regards to international law.[10]

NLWs are intended to provide commanders with additional capabilities that supplement, but not replace highly lethal force. NLWs act as force multipliers enabling U.S. forces to discourage, delay, or prevent hostile action, limit escalation where lethal force is not preferred, protect friendly forces, and temporarily disable facilities and equipment.[11] Unlike conventional weapons that destroy their targets principally through blast, penetration, and fragmentation, NLWs employ means other than gross physical destruction to prevent the target from functioning. NLWs are intended to have one, or both of the following characteristics: to have relatively reversible effects on personnel and material, and to affect objects differently within their area of influence.[12] As stated in the Air Land Sea Application Center manual on the tactical employment of non-lethal weapons, "NLWs provide commanders the flexibility to influence the situation favorably with increased safety to U.S. Forces while reducing risk of both noncombatant fatalities and collateral damage."[13]

The pursuit of non-lethal capabilities is not necessarily new. Towards the end of World War II, German scientists experimented with a high-energy acoustic vortex technology designed to destroy material and disable men. This weapon looked like a large cannon and sent out a shock wave similar to a sonic boom that in theory could have downed a B-17 bomber. Its effects

were disabling, rather than destructive, against soft targets like people.[14] The defoliant "Agent Orange" was used by American forces essentially as an area denial weapon during the Vietnam War.[15] Current technologies considered to fall under the realm of non-lethal are:

> Electromagnetic technologies (such as lasers and microwaves)
> Electric technologies (including stun guns and tasers)
> Chemical, biological and biochemical technologies (such as tear gas, malodorants and toxic incapacitating agents)
> Mechanical technologies (including nets and barriers)
> Acoustic technologies (such as infra- and ultrasonic generators)
> Kinetic technologies (such as rubber and plastic bullets)[16]

Tables outlining existing and emerging non-lethal capabilities can be found in Appendix A.

While it is important to understand the context of the non-lethal weapon term, it is also equally important to distinguish what non-lethal weapons are not. The DOD does not include psychological operations, electronic countermeasures, precision lethal weapons, computer network attack, or most weapons associated with information operations in its definition of non-lethal weapons.[17]

In 2000, the Joint Non-lethal Weapons Program (JNLWP) conducted a year-long Joint Mission Area Analysis (JMAA) to identify and analyze known operational deficiencies, review required operational capabilities, and examine the ongoing development of NLW technology. In 2001, the JMAA released its analysis dividing future NLW requirements into three core capabilities and eight functional areas. These were:

- Counter-personnel
    - Crowd Control
    - Incapacitate Individuals
    - Deny Area to Personnel
    - Clear Facilities/Structures/Areas

- Counter-material
    - Area Denial to Vehicles (land, sea, and/or airspace)
    - Disable/Neutralize Vehicles, Vessels, Aircraft, and Equipment

- Counter-capability
    - Disable/Neutralize Facilities and Systems
    - Deny Use of Weapons of Mass Destruction[18]

The Need for Non-Lethal Weapons in Major Combat Operations

In December 2002, the Department of Defense's Joint Requirements Oversight Council (JROC), chaired by the vice chairman of the Joint Chiefs of Staff, approved a mission need statement for a family of non-lethal capabilities. The statement read,

> The U.S. military lacks the ability to engage targets that are located or positioned such that the application of lethal, destructive fires are prohibitive or would be counter-productive to the U.S. objectives and goals. Operational and strategic applications of non-lethal weapons do not exist. At the operational level, U.S. military forces lack the ability to engage targets located where the application of lethal fires would be counterproductive to overall campaign objectives. At the strategic level, the U.S. needs a non-lethal capability that can help defuse volatile situations, overcome misinformation campaigns, and break the cycle of violence that often prolongs or escalates conflict.[19]

The panel also found that:

- Non-lethal capabilities apply and have expressed utility across all types of Military Operations Other Than War and Major Theater War.

- Non-lethal capabilities have clear applications for tasks associated with Force Protection, Movement/Maneuver and Employing Forces/Fires, with fewer applications for Intelligence, Surveillance, and Reconnaissance (ISR) and Command and Control (C2).

- Non-lethal capabilities complement lethal weapons and, for some tasks, offer advantages or unique contributions. This is true across the spectrum of threats and crises.[20]

Various opinions have been presented favoring the development and employment of non-lethal weapons in combat. One of the most prevailing arguments deals with the likelihood that future combat operations will occur in urban environments. According to Joint Publication 3-06 on Joint Urban Operations:

Rapid urbanization is changing the physical and political face of nations. Demographic studies indicate a vast increase in the number and size of urban areas throughout the world; medium sized towns have become large cities, and large cities have become the modern megalopolis. This population concentration has ensured that many future military operations will be taking place in urban areas. US forces must be prepared to conduct effective joint urban operations more than ever before.[21]

It is estimated that by the year 2010, 75 percent of the world's population will live in urban areas. The increased population and accelerated growth of cities have made the problems of combat in built-up areas an urgent requirement for the U.S. military. Urban areas are expected to be the future battlefields and combat in urban areas cannot be avoided.[22] As a result, it will be much more difficult to differentiate friend from foe from non-combatant as civilians and combatants occupy the same factor space. Consequently, enemies are likely to exploit this situation by intentionally embedding within innocent civilian populations.

In this urban environment there exists the potential for massive collateral damage to persons and property. With the continuing expansion of media and information organizations in both size and scope, coverage of any unintended collateral damage will be distributed with near real-time speed. Some have christened this the "CNN effect" in which military operations are being dissected and scrutinized at the highest levels to determine the potential media fallout from civilian casualties.[23] Certain domestic news services may provide accurate backgrounds for objective analysis of the events and censor graphic images in the interest of good taste. However, the same discretion will not be universally shared by all global news outlets. This will likely provoke international reaction and bolster an already apparent public intolerance towards the loss of innocent life. This could have disastrous political implications to an operation. Consideration must be taken to execute major combat operations without alienating the local population or arousing international outrage.[24]

The enemy is acutely aware of the predicament that we face while engaged in urban combat operations. In recent conflicts in Iraq and Afghanistan, the enemy has intentionally hidden weapons and taken defensive positions inside sensitive areas such as mosques, hospitals, and schools in the hopes that an attack might gain them favor in the court of public opinion.[25] Both state and non-state enemies, with little to no regard for the Law of Armed Conflict, have emplaced high value targets in the

vicinity of high collateral damage prone areas. Additionally, they have shown their willingness to ignore international law by attempting to deter attack through the use of human shields. Should an attack occur the enemy will likely employ misinformation techniques aimed at exacerbating this situation. In this environment, non-lethal weapons can minimize opportunities for adversaries to provoke negative public opinion against our cause.[26] Targets that might otherwise be considered politically or militarily off-limits may become subject to attack because the risks of incurring collateral damage or civilian deaths are minimized.[27]

Another argument for the use of non-lethal weapons in combat operations encompasses the concept of reversibility. Attaining a military objective while minimizing unnecessary loss of human life and gross physical destruction will aid in the transition to security and stability operations upon conclusion of combat operations. Crucial support during the early months of reconstruction and stabilization may be lost if valuable infrastructure cannot be restored quickly. Military planners recognized this during Operations Desert Storm and Allied Force. Instead of destroying essential electrical power targets in Iraq and Serbia, munitions were employed that dispersed strands of carbon-graphite wire. These wire strands shorted out transformers, caused flash fires, and effectively shut down power in Baghdad and 70 percent of the former Yugoslavia.[28] The strategy postulated that the attacked nations would eventually need the electrical distribution capacity

during the post-conflict rebuilding process. Ridding the power facilities of graphite wire was theorized as being a quicker and more cost-effective solution than the alternative of rebuilding a destroyed power plant.[29]

The final argument supporting the need for NLWs in combat deals with the maturity of technology.[30] Advancements in technology have altered the way we have fought wars in the past and will continue to do so in the future. For example, in World War II, one thousand sorties of B-17s with nine thousand bombs were required to destroy a single target. Today, the U.S. Air Force can destroy 16 different targets using only one B-2 sortie delivering 16 global positioning system (GPS) bombs.[31] The notion of a contemporary air operation using World War II era unrestricted, non-precision bombing techniques is politically and socially unthinkable. In a sense we have become victims of our own success. Our technology has proven to be so overwhelming and so precise that it has drastically affected the perception of combat. Wars are expected to be short, simple, and executed with precision. There is very little room for error within this expectation. Even the textbook tactical execution of a precision lethal engagement can have a run-in with the law of unintended consequences as evidenced by the inadvertent 1999 bombing of the Chinese embassy in Belgrade during Operation Allied Force.

NLWs are intended to be used in conjunction with lethal weapon systems to enhance the latter's effectiveness and efficiency in military

operations.[32] However, as technology continues to evolve it is conceivable that the capabilities and effectiveness of some future NLWs will surpass lethal counterparts. Future NLW capabilities include high-energy laser weapons systems, short-pulse, laser-induced plasma technology, and high power microwave technology.[33] The capabilities and effectiveness of such weapons could far exceed the value of bullets and bombs in terms of area denial to personnel or material and particularly in disabling systems or facilities. It may be possible to influence targets that are normally unaffected by, or considered undesirable to attack with, normal lethal munitions. Examples of such targets are those that are subject to deep burial making them impregnable to even the deepest penetrating bunker buster warheads. A strike on a chemical, biological, or nuclear facility or delivery system using blast or fragmentation weapons may not be desirable or feasible. A preferred alternative may be an attack with an NLW as a means to disable such a system without risking nuclear, biological, or chemical release.

Challenges to the Development and Implementation of NLWs

There are many challenges and hurdles when considering NLWs as a mainstay of military force. International law and arms control treaties play a significant role in their development and employment. Entire research papers have been written just on this subject alone and delving into a detailed analysis of the many legal interpretations regarding NLWs is beyond

the scope of this paper. However, a summary of pertinent laws and applicable treaties is provided to convey a basic understanding of the many legal facets and challenges that need be addressed.

The general principles of the Law of Armed Conflict play a significant role when considering the employment of NLWs. Critics of NLWs often cite the principle of distinction when arguing against the use of non-lethal technology. The principle of distinction obligates a commander to distinguish valid military objectives from civilians or civilian objects before attacking.[34] The concern among opponents of NLWs is that a commander will be more likely to use NLWs in situations where enemies are mixed with civilians than if they were limited to just a lethal option. Distinction goes hand in hand with the principle of proportionality. This proportionality principle weighs the military advantage one expects to gain from the unavoidable and incidental collateral damage to civilian life and property that will result from an attack.[35] Proponents of NLWs often use the proportionality argument to counter the distinction line of reasoning.

The principle of unnecessary suffering must also be considered in the development of NLWs. This principle prohibits the use of any weapon or material calculated to cause unnecessary suffering to combatants.[36] Like much in the sphere of law, unnecessary suffering is subject to vast interpretation. For example, the Active Denial System (ADS) is a non-lethal, counter personnel, directed energy weapon that operates by generating a

focused beam of millimeter waves. These millimeter waves induce an intolerable heating sensation on an adversary's skin, repelling the individual with minimal risk of injury. The sensation immediately ceases when the individual moves out of the beam and causes no permanent injury.[37] One man's intolerable heating sensation is likely another's unnecessary suffering and this issue continues be debated.

The Biological Weapons Convention and the Geneva Protocol forbids the development, production, and employment of any biological weapon, whether lethal or non-lethal.[38] The use of permanently blinding laser weapons is also prohibited by a protocol to the Inhumane Weapons Convention. The effect of the Chemical Weapons Convention on non-lethal weapons is a bit more complicated.[39] The 1993 Chemical Weapons Convention prohibits the development, production, stockpiling, and use of chemical weapons.[40] This effectively bans the use of non-lethal chemical weapons against enemy personnel. However it does allow for the use of non-lethal chemical weapons for anti-material purposes as long as the weapons do not incapacitate or cause permanent harm to personnel.[41]

A final area within international law that must be considered in the development and employment of NLWs is the principle of *hors de combat*. This principal prohibits attacks against enemies who cannot, do not, or cease to participate in hostilities due to wounds or sickness.[42] These include enemies who are injured or incapacitated. It is conceivable that NLWs could

intentionally produce an incapacitated enemy who then could not be attacked under international law.[43] This obviously has significant consequences on the battlefield regarding the follow use of lethal force.

Like their lethal weapon counterparts, NLWs are required to undergo an intensive legal review to ensure that the weapons or systems are consistent with all applicable domestic and international laws.[44] Current U.S. policy is to work within the guidelines of international law and not attempt to alter treaties or agreements. Many critics of NLWs cite legal concerns to discourage the use and development of non-lethal systems. The paradox to this legal debate is that it appears to be much more complicated and difficult to use non-lethal force on an enemy than it is to use lethal force.

Another significant impediment in fielding non-lethal capabilities involves measures of effectiveness. While a variety of capabilities have been conceptualized, the unknown effectiveness of many of these technologies may discourage their employment. In a historical context consider the aforementioned carbon-graphite wire munitions employed in Iraq and Kosovo. These weapons worked as advertised in disabling the targeted power distribution capacity of the two countries. However their effects were short-lived as enemy forces were able to restore power relatively quickly by removing the wires and resetting circuit breakers.[45] In terms of future technology consider the Active Denial System. The burning sensation that it produces has achieved the desired effects on various groups of volunteers.

Those volunteers preferred to move away from the weapon system rather than experience the intense discomfort that it generated. Achieving identical results on a group of agitated fanatics during combat operations might be a different story. Quite simply, the level of motivation between the two groups of individuals cannot be objectively compared.[46] Lethal weapons produce absolute destruction and death that tend to have relatively long-term and irreversible effects. Consequently, the threat of lethal force typically induces some semblance of deterrence. It is not yet clear what type of deterrent effect many NLWs may evoke.[47]

A final contention posed by critics of NLWs is that despite their humane intentions, NLWs may actually expand the spectrum for the employment of force. One possibility is that NLWs will lower the threshold for the use of force and accelerate escalation of a situation. If a commander tries to gain control over a tenuous situation before it can escalate he might attempt to do so by using non-lethal force. This argument has been used by both sides of the NLW debate. Proponents of NLWs say that this is one way to deter a situation while critics maintain that force will be introduced into a situation where it might not otherwise have been.[48]

Conclusion

The employment of non-lethal weapons has implications at the tactical, operational, and strategic levels. The nature of warfare has dramatically

changed through the course of history. The likelihood of future combat operations taking place in urban areas is practically unavoidable. The evolving nature of warfare demands that we develop and implement innovative strategies and solutions to combat complex battlefield problems. Collateral damage to innocent lives and property are events that can have staggering strategic and political effects on a conflict. Gone are the days when the loss of tens of thousands of lives in a single day provoked little reaction. Whether we like it or not, future battles will bear the scrutiny of public opinion as delivered to them through the juggernaut that is mass media. Savvy enemies have adapted to take advantage of information mediums in order to exploit this perceived weakness in international public sentiment. NLWs are desperately needed to counterbalance the potentially catastrophic effects of unwanted collateral damage.

NLWs indeed have utility in major combat operations. Situations that warrant their consideration include those where the cost in damage and lives incurred by lethal weapons is simply too high. Non-lethal alternatives should also receive merit if identical results can be achieved using lethal or non-lethal options. This is not to preclude the use lethal weapons, rather to say that lethal effects may not be desired compared to non-lethal ones. In the near future some non-lethal capabilities may actually exceed those of lethal force particularly in the area of chemical, biological, and nuclear counter-capability. Lest we forget our recent history, consideration must be given to

importance of post-conflict rebuilding and winning the hearts and minds of those ravaged by war. The employment of NLWs may alleviate some innocent suffering during wartime and expedite a return to normalcy with a lessened financial impact.

There are many critics of non-lethal weapons and their arguments warrant consideration. Non-lethal weapons are a tool for achieving military goals while abiding by the principles of the laws of warfare of military necessity, proportionality, discrimination, and avoidance of unnecessary suffering. Continued vigilance must be exercised to ensure that NLWs are developed, implemented, and employed in accordance with international law. The uncertain level of effectiveness of unproven technology will be a continuing challenge to the operational attainment of some NLWs. However, this concern is not unique to NLWs as lethal weapon systems often undergo similar growing pains. A key will be to not unnecessarily hasten the introduction of unproven technologies until their effectiveness is understood. Sound doctrine, training, and rules of engagement will be needed to continue down the road towards NLW implementation. Just as lethal weapons can be non-lethal in the hands of untrained personnel, non-lethal weapons may prove to be deadly if improperly employed. Developed, implemented, and employed correctly, NLWs possess tremendous potential that can deliver much needed capabilities and options to our operational commanders and planners in major combat operations.

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Appendix A: Tables

Table 1: Existing and Emerging Non-Lethal Technologies

Electromagnetic	Chemical	Acoustic	Mechanical and Kinetic
ELECTRICALS Pulsed current Sticky Shocker *Stun guns* Taser mine Direct current RADIO FREQUENCY Non-nuclear EMP MICROWAVE High Power Microwaves MILLIMETER WAVE Millimeter wave projector INFRARED Chem. oxygen iodine lasers CO2 lasers HF/DF lasers Solid state lasers VISIBLE Laser scattering obscuration *Laser illuminators* Holograms Laser light bullets Isotropic radiators *Flashes and flares* *Strobes* ULTRAVIOLET Laser Ionizer	OBSCURANTS *Smokes* REACTANTS Supercorrosives Combustion alteration-air/fuel Combustion alteration-fuel viscosity Lubricant contaminants Depolymerizers Embrittlers Emulsifiers MALODERANTS *Skatole* *Mercaptan* CALMATIVES RIOT CONTROL AGENTS OC (pepper spray) *CS* *CN, Mace* ANTI-TRACTION FOAMS Sticky foams Rigid foams THERMOBARRIC COMPOUNDS NANOPARTICLES Magnesium oxide	AUDIBLE INFRASONIC ULTRASONIC	BARRIERS *Caltrops* *Tire spikes and strips* ENTANGLEMENTS *Portable vehicle arresting barrier* Running gear entanglement system Net mines CLOGGERS Vessel Exhaust stack blocker BLUNT IMPACT DEVICES *Rubber balls* *Modular crowd control munitions* *40mm crowd dispersal munitions* *66 mm vehicle launched NL grenade* *Liquid filled* *Bean bag* *Baton* *Water stream cannon*
Combined Technologies		**Ancillary Technologies**	
Flash Bang Devices Multi-sensory Distraction Device 66mm Vehicle Launched Grenade		MARKERS *Dyes – Liquid, foam, smoke* *Fluorescent* *Invisible – UV light visible* *Paint ball guns* NON-LETHAL CASINGS ENCAPSULANTS TAGGERS – ACTIVE	
Italicized text signifies existing technologies			

Source: Joint Non-Lethal Weapons Program Non-Lethal Weapons Joint Mission Area Analysis/Joint Mission Need Analysis (JMAA/JMNA), Final Report, December 2000, 15-18.

Table 2: Master Technologies List

Technology	Rationale
1. Millimeter Wave Electromagnetic Radiation	Previously classified. See Active Denial System under Advanced Concept Technology Demonstrations below.
2. Chemical Oxygen Iodine Lasers	COIL technology offers unique contributions to the non-lethal counter-materiel and counter-capability areas by providing the capability to strike targets with ultra-precision, controllable effects from long standoff ranges while minimizing collateral damage. A derivative of the technology being used on the Air Force Airborne Laser program, COIL has the highest technical maturity and offers the greatest potential for implementation in the near to midterm. It is the central element of the Advanced Technology Laser ACTD. Technical challenges include scaling down of the laser gain module, beam conditioning and control in a dynamic motion environment, and management of the chemical process effluents. Technical risk is considered medium.
3. Anti-Traction	Anti-traction or slippery substances can provide the capability to inhibit the fire movement of vehicles or individuals through treated areas. This would provide a capability to deny access to or through an area in a number of operationally useful situations. Although some development has taken place and the concept has been successfully demonstrated, additional work is necessary to improve the persistence and concentration of these materials in operational environments. Anti-traction material payloads can be readily integrated into a number of existing ground and air delivery systems and platforms and can be made operational in the near term.
4. Non-Lethal Delivery /Deployment	Non-lethal munitions must be capable of deploying and dispersing their payloads in a non-lethal and controlled manner. Technologies that reduce the kinetics of the delivery process such as frangible and combustible materials enable the development of munition casings that break up into many low mass, low-velocity fragments. Other options include use of materials that are combusted during payload deployment and drogue parachute applications. The development of encapsulation materials that will activate/release their contents when subjected to specific stimuli such as a mechanical pressure, a specific temperature, light of a specific wavelength, etc., would be very useful operationally. This, coupled with the ability to produce capsules of various diameters down to 100 microns, could considerably broaden the range of options for delivery and deployment of numerous non-lethal payloads. The existence of such materials will enable the development of common munitions capable of carrying several types of non-lethal payloads fired from a large number of existing weapons such as grenade launchers, mortars, field artillery, and aircraft ordnance.
5. Malodorants	Malodorous substances can be very useful operationally in counter-personnel applications where the minimum level of force is appropriate or as a first measure to prevent escalation. By themselves, these extremely foul, putrid smelling substances can be very effective first-level discriminators of motivation and intent. In combination with other non-lethal technologies, such as bright light flashes and loud explosive bangs, malodorants can effectively produce multi-sensory overload of individuals and groups to temporarily incapacitate/distract them. The technology of malodorous substances is mature.

Source: Joint Non-Lethal Weapons Program Non-Lethal Weapons Joint Mission Area Analysis/Joint Mission Need Analysis (JMAA/JMNA), Final Report, December 2000, 15-18.

Table 2: Master Technologies List

Technology	Rationale
6. Calmatives	This technology was selected because of its very broad applicability and utility. Sleep agents or calmatives that could render individuals incapable of continuing their actions for various periods of time in a controllable fashion would be extremely useful in a very large number of operational scenarios. To make them most useful, calmative agents should be capable of being used in situations involving a mix people of varying ages and physical characteristics. Consequently, the primary technical challenge will be in developing agents that produce consistent, safe effects over broad ranges of the human population, and be made relatively insensitive to dosage. Additionally, mechanisms must be found to enable absorption into the body in a variety of ways such as inhalation or through skin. Research is also needed to accelerate the onset of the effects of these agents. This would enable the safe and quick incapacitation of individuals in certain critical situations. The technical challenge associated with this effort is deemed to be significant.
7. High Power Microwaves	Classified.
8. Rigid Foam	Rigid foams provide significant utility for creating temporary barriers, particularly in entryways, and for disabling the support functions of facility existence (i.e., power distribution, communications, etc.). Additionally, they can be used to disable vehicles and other equipment by jamming moving parts. This capability has potentially broad application in the counter-materiel and counter capability areas. Technical challenges still exist to reduce the hardening/curing time and to increase structural strength. Additionally, other alternatives to deliver and deploy the foam payloads, such as binary configurations, are needed to enable standoff and long-range delivery when applicable.
9. Tagging, Tracking and Locating	The technology associated with luminous or covert dyes and paints is mature with the majority of the effort required in developing delivery/deployment means (range and non-disclosure) and integration into the necessary platforms. Significant work is required to develop minute tagging devices capable of being tracked and located, as well as their delivery/deployment means.
10. Nanoparticles	Nanotechnology was chosen because of its significant potential contribution in reducing the harmful effects of releases of chemical and biological agents. Although early in development, the concept using reactive nanoparticles to decompose chemical agents or to destructively absorb biological agents shows considerable promise, and results of experimentation are very encouraging. Nanotechnology also has significant potential of advancing materials development by enabling the production of very high shear and tensile strength fibers that are extremely lightweight. Such material could enable the development of new, highly effective entanglement systems that can be used for both non-lethal counter-personnel and counter-materiel applications. Technical challenges include the development and testing of agents to counter the various threats, and developing the capability to produce these substances in sufficient volume.

Source: Joint Non-Lethal Weapons Program Non-Lethal Weapons Joint Mission Area Analysis/Joint Mission Need Analysis (JMAA/JMNA), Final Report, December 2000, 15-18.

Table 2: Master Technologies List

Technology	Rationale
11. Low Energy Laser Scattering and Dazzling	The capability to temporarily obscure an adversary's vision can provide significant military advantage in a number of situations. The use of low power, eye-safe lasers against individuals for this purpose has been proven effective in evaluations conducted during military operations. However, low-power laser technology also has the potential to provide this capability against large groups yielding similar non-lethal operational utility at a larger scale. This can be done by either directly illuminating the adversary group with an eye-safe, broader laser beam or by illuminating an external medium, such as an airborne aerosol cloud, resulting in the scattering of the laser light and creating a "wall of light." Challenges exist in the accurate characterization of effects on the human eye and in overcoming issues of public perception associated with laser technology.
12. DF/HF Lasers	Applications of pulsed Deuterium-Fluoride (DF) and Hydrogen-Fluoride (HF) laser technology have direct applicability in the non-lethal counter-personnel area by providing the unique capability to incapacitate individuals from standoff ranges of up to 500 m. Mounted on a vehicle or eventually man-portable, these devices produce pulsed energy projectiles that travel instantaneously and produce controllable effects. Technical challenges include the development of a robust, practical field device, successfully developing the capability to control the effects and characterizing the human effects.

Source: Joint Non-Lethal Weapons Program Non-Lethal Weapons Joint Mission Area Analysis/Joint Mission Need Analysis (JMAA/JMNA), Final Report, December 2000, 15-18.

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